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PERFORMANCE IMPROVEMENTS USING LEAN ERGONOMICS PRACTICES: APPLICATION IN PORK MEAT INDUSTRY

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ABSTRACT
This work was carried out in a company dedicated to the production and marketing of meat products, this arises from the need to improve the process of sausages due to the waste generated during their process, so the current status was evaluated to see the efficiency of the process through Lean Manufacturing tools and evaluating the ergonomic risks. The main Lean tools used were Value Stream Mapping (VSM), SIPOC and Kaizen, for the ergonomic evaluation were considered the REBA and NIOSH methods. As a result, the most risky activities were obtained, as well as wastes of time and movements due to improper postures and procedures during their process that affect and delay the flow of the same process. After implementing the proposals, each activity was evaluated again, a future VSM was carried out, where a reduction of 33.18% of the cycle time was presented, making this process more efficient than before.

INTRODUCTION
The continuous change and the client demand (fast deliveries, high quality and competitive prices) forces organizations to be constantly searching for solutions that generate greater productivity and efficiency, working daily to generate new competitive advantages, to respond to each one of the exposed challenges, to differentiate itself and thus to stay in market, (Pedraza, 2010). The organization under study is a benchmark nationwide of exportation and is dedicated to the production and marketing of pork, where efficiency for the company represents one of the most important elements of study.

Lean Manufacturing is a concept that appears more and more in companies that support human needs and their well-being. We evaluated 5 representative materials with different authors in order to analyze and identify each type of inclination in the production systems where they have implemented lean manufacturing tools and ergonomic methods that complement risk assessment in work stations. In the investigation of Koykoulaki, T. (2014) discrepancies were identified between the practices of efficient manufacturing theory and reality (Relationship between JIT and the increase in stress and pressure among employees). Cullinane, Bosak, Flood, & Demerouti (2014) performed an identification of the employee in a positive reaction to feedback, the need for accountability of employees based on supply and demand through various training, motivation, promotion. Morse in 2014 found the need for quick participation of employees to adapt and meet demands, the right combination of security, and satisfaction to avoid conflicts. Arezes, Dinis, & Alves (2014) identified and implemented the Lean principles, misunderstandings of similar inappropriate solutions for all situations. The literature notification reports an improvement in stress reduction in lean manufacturing. Rose, Deros, Rahman, & Nordin (2011) added that to work properly with suppliers and customers, the implementation of Lean must be done from the inside, through the participation and collaboration of employees.

The model about the integration of ergonomics and lean manufacturing systems based on the various tools has been presented in various organizations: it is associated with the inclination of the manufacturing system procedures used in each phase of the ergonomic tools and methodologies that introduce an additional security perspective, (Srinivasa & Malay, 2016). A study carried out in the meat industry by Gastelo & Sandoval, (2016) where they applied a questionnaire on musculoskeletal injuries associated with repetitive movements where considerable results were obtained and, on average, 50% suffered from some injury or illness, generating costs for having safe and ergonomic working conditions. The search for improvements in the process of the different

products brings the need to evaluate and measure the current situation during the manufacturing activities both with lean manufacturing tools and ergonomic methods, in order to achieve a better organizational performance and increase the competitive level to an international level, offering advantages in productivity, quality and safety. Given the situation, the following is stated: Will the implementation of Lean Ergonomics Approach in the process of ham in the processing area improve the efficiency of its operations?

Dombrowski, Reimer, & Wullbrandt, (2018), comment that the integration of new lean manufacturing methods and tools is necessary for the operational implementation of human factors and ergonomics. This allows employees and senior managers to implement human factors and ergonomics in their daily work routines, in particular they can integrate methods to assess and improve ergonomics. While Dos Santos, Vieira, & Balbinotti, (2015) mention that the application of lean manufacturing should make a direct correlation between the vision of working conditions with a support tool known as Ergonomics; Each continuous improvement made in any work environment, this correlation can be carried out to adapt the improvements to the operator. The combination of Lean thinking and ergonomics is the result of a system where not only the worker is the most efficient, but also safe and comfortable while trying to produce the best possible product, Mulyati, G., Suharno, & Muharom, MA (2015). The Lean theory helps to reduce stress in lean manufacturing through misunderstandings, internal collaboration between employees and managers. All this together represents an ergonomic perspective through LM, Cirjaliu, B., & Draghici, A. (2016).

Objective

Implement the Lean Ergonomics Approach in the manufacturing processes of the processing area to improve the efficiency of its operations.

MATERIALS AND METHODS

This research is observational, transversal, not experimental, 100% of plant operators will be evaluated in the process of making ham, without considering the worker who is covering any disability, absence or illness. The following describes the procedure carried out for the development of the research, the techniques, tools and instruments used for the collection of information.

Subject under study

This study is conducted on a company dedicated to process and market pork at national and international level, specifically the process of making ham has a capacity of 6 tons of daily production, it has 5 people working and its main customers are national.

Procedure

Elaboration of Current VSM: In this stage the operations are analyzed through the Value Stream Mapping (VSM) tool to know the current situation of the process, where the following elements should be considered:

- Elaboration of a Process Diagram. Analyze the supply chain in detail of the process through the SIPOC diagram.
- Identification of Ergonomic Risks. Identify risks in each one of the operations of the process using the Nordic questionnaire of Kuorinka (1986) and the BRIEF / BEST method, determining its risk condition.
- Evaluation of Ergonomic Risks. Evaluate the activities in the work station using ergonomic methods according to the results of the risk identification in order to define redesign options that reduce the risk and obtain acceptable levels of exposure for the worker.

Elaboration of future VSM: In this stage, ergonomic improvements will be integrated in a future VSM to compare the previous efficiency with the current one in the operations of the process and the assessment of the ergonomic risks found, it should be considered:

- Design of Improvement Proposals. Establish improvement actions using lean tools to reduce the waste that occurs during the process, considering the conditions and ergonomic factors.
- Evaluation of Ergonomic Risks. Evaluate the activities in the work station with the implementation of improvements to verify changes as interaction between the human being and the elements used in the operations of the process.

Materiales

- Photographic camera
- Software Ergo Soft Pro 4.0
- Microsoft Visio Professional 2016

RESULTS AND DISCUSSION

The identification of risks was carried out through the BRIEF / BEST method. It was evaluated (see table 1) to know the aspects that generate risks during the process.

Table 1. Risk identification using BRIEF/BEST method

	PROCESS	ACTIVITY	**Risk value**	**Priority**
BRIEF value Conversion factor	Ham sausage	1	27	Medium
BRIEF value Conversion factor		2	52	Very High
BRIEF value Conversion factor		3	26	Medium
BRIEF value Conversion factor		4	36	High
BRIEF value Conversion factor		5	72	Very High
BRIEF value Conversion factor		6	36	High

According to the method, all of the activities of the process have an evaluation, see Table 1, of medium risk are: Fill hopper and Prepare molds, high risk are Stuffing and weigh, and arrangement in a cage, and the highest risk are Prepare the machine and Mold and Cover. With the results of the Nordic questionnaire and the BRIEF / BEST it was determined that the methods applied for risk assessment are REBA (Rapid Entire Body Assessment) (see figure 1) and NIOSH (see figure 2), both in different postures

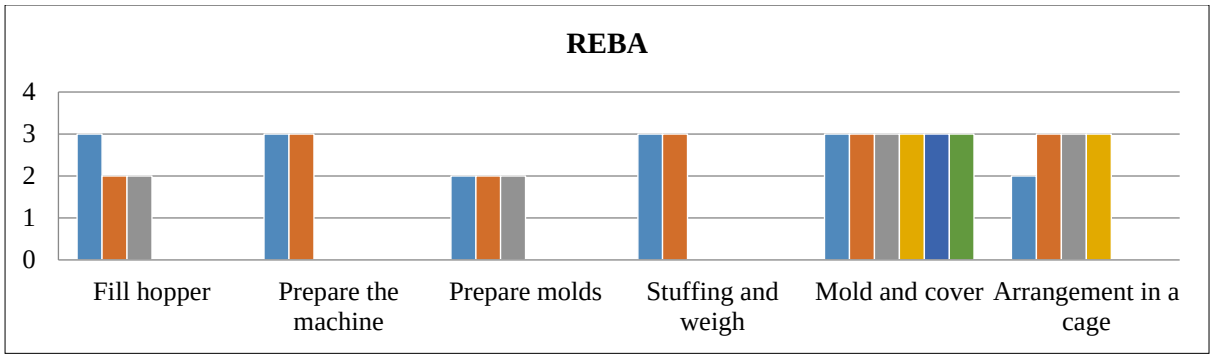

Figure 1. Activities evaluation with REBA method.

The action levels according to the REBA method are 1 = Not necessary; 2 to 3 = It may be necessary; 4 to 7 = Necessary; 8 to 10 = Needed soon; 11 to 15 = Immediate action.

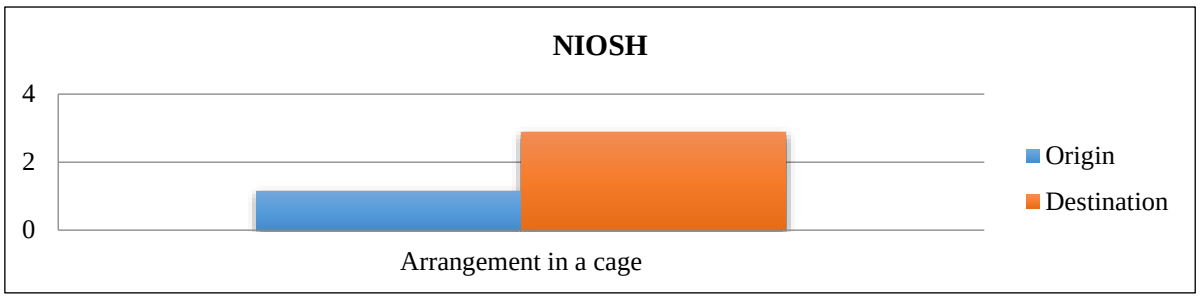

Figure 2. Activities evaluation with NIOSH method.

According to the NIOSH method, three risk zones can be considered according to the IL values obtained for the task. Limited risk (IL<1). Moderate increase in risk (1 < IL < 3). Accelerated increase in risk (IL > 3).

Table 2. Risk representation

NIOSH	REBA	RISK
1<	**1-3**	LOW
1-3	**4-7**	MEDIUM
>3	**8-15**	HIGH

Finally, in the evaluation a representation of the level of risk and the score that each method handles was made (table 2). In addition, all the ergonomic risks of the process that were obtained from the methods used in all the activities that are carried out in the processing of smoked sausages were graphically created using the value stream mapping tool. See figure 3.

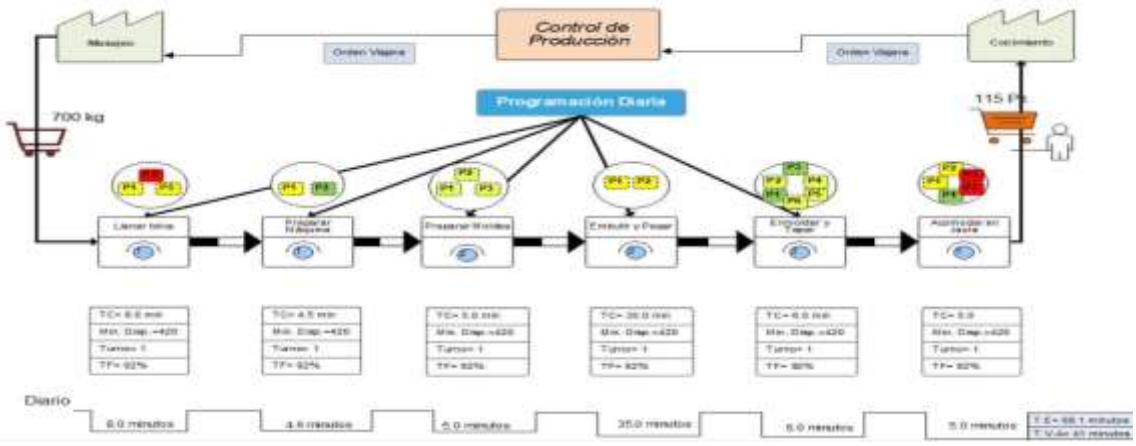

Figure 3. Actual VSM with Ergonomic Evaluation

The VSM represents the current situation of the ham process divided into its operations, indicating the way in which the process flows, the requirements and the flow of the customer information (cooking) to the supplier (massage). In addition, it shows the result of the ergonomic evaluation for each activity and its level of risk.

Improvement proposals design.

In the process there are six activities, which were divided into a total of 21 positions. The results of the evaluation showed that 4 positions are low risk, 14 are medium risk and the rest are critical with a high level of risk, which should be improved to avoid possible injuries, work diseases in the future. From the above, there is a need to generate proposals that help improve the process, as well as reduce risks. In the evaluation, critical positions were

found that could damage the health of the operator, which is why you have the following proposals regarding postures per activity.

Fill hopper: To reduce the risk level in the three positions is suggested an adaptation to the cart (see Figure 4) in which the mixture is transported to be stuffed and thus the height is suitable for the operator so your body is not inclined to it and in such a way the operator will not have to lift over passing the maximum lifting level in his arms.

Figure 4. Cart folding adaptation.

Prepare molds: There are three postures of medium level, so it is proposed that the pallet where the molds are placed at an optimum height for the operator, see figure 5.

Figure 5. Height proposal for the pallet.

Stuffing and Weighing: To minimize the variation of the sausage time, taking as reference 5,250 seconds that were obtained by means of samples taken in the process that give the specified weight, which is 5,250 + - 0.050, without wasting time adding or removing paste, for reach the correct kilograms.

Arrangement in a cage: It was observed that in positions 1, 2 and 4, an average level of risk was obtained and position 3 with a high level of risk, which suggests a poka yoke (see figure 6) to avoid errors in the accommodate molds and fully approve the space of the cage, the operator must perform its activity without exceeding the weight recommended by NIOSH method in addition to raising their arms to the height of their shoulders, it is important that the operator pivots at the time of making this activity, in this way there will be no angle of action and this avoids risk of injury.

Figure 6. Poka Yoke's representation.

The process was evaluated again with the same ergonomic methods, but now with corrections in the positions of the operators, see figure 7.

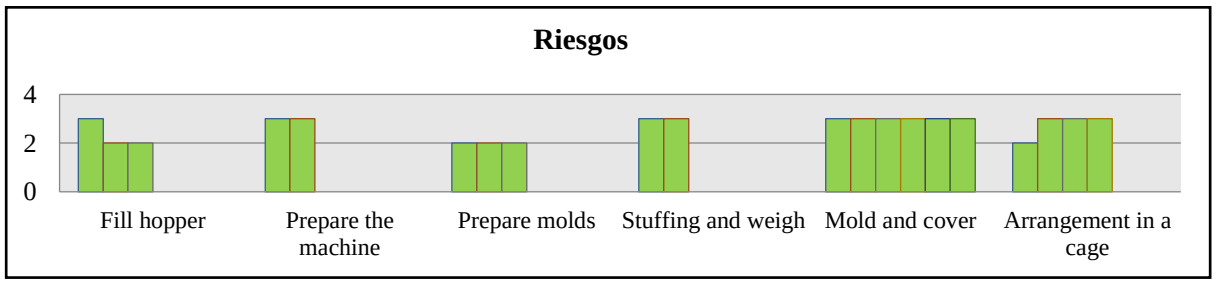

Figure 7. Risk processes are a new evaluation

With the new evaluation all risks where previously they were medium and high level were reduced and now they are of low risk. Next, the future enhanced VSM is represented, including the proposals, and the new ergonomic evaluation of the process was added, see figure 8.

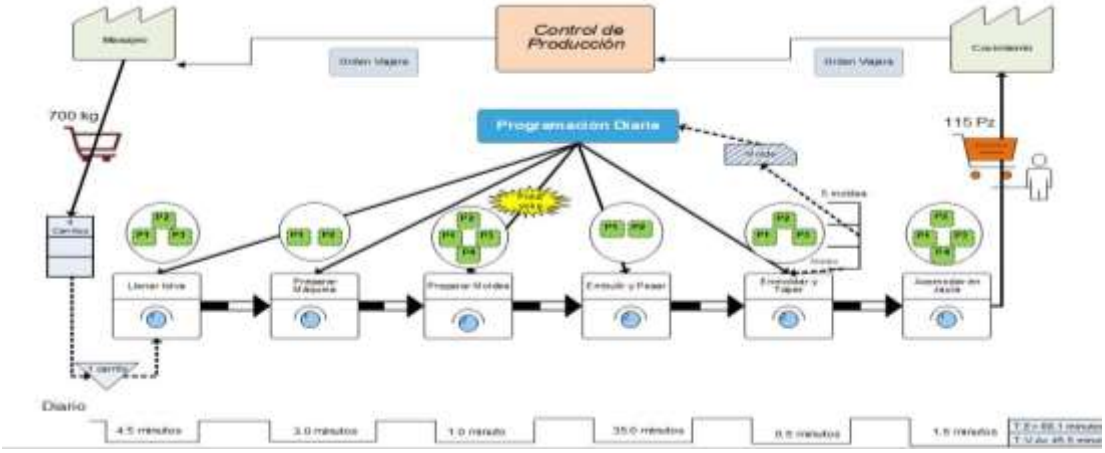

Figure 8. Future VSM with Ergonomic Evaluation

The process efficiency was calculated by making an estimate for the time reduction in the activities, which were considered by subtracting the time from the activities of each stage of the process that the operator performs and that do not add value during the process of a batch. A reduction of time of 22 minutes is calculated, which in percentage represents 33.18% for a batch of 115 pieces.

CONCLUSION

Based on the study and results of the Lean Ergonomics project applied to the ham sausage process, the objective is to increase efficiency through Lean tools and ergonomic evaluations, improving on average by 33.18% the operating times of each activity, In turn, it reduces and / or eliminates the level of risk, allowing the operator to work in adequate conditions and to do his job in a safe manner. Implementing the improvements has a cost, however, not meeting the needs of the process and the human factor generates accidents, illnesses that lead to days of disability and even death, causing a higher cost for the organization and damage to the operator.

Lean Ergonomics is a novel tool with scarce information, so with this project it was possible to contribute a little more information to the research about the application of this tool that is obtained by integrating lean manufacturing and ergonomics, which together contribute to the reduction of human activities that are considered as waste, making a process more efficient and free of ergonomic risks. This tool looks for the way to combine Lean with the ergonomic evaluation and apply them in different processes and in which a VSM was used to map the process where areas of opportunity to improve were found.

According to Kasper, (2017) Lean Ergonomics integrates work environment factors into a lean manufacturing "Value Stream Mapping" tool by identifying possible risks at the work station where it evaluates each work activity in the process. The risks that may exist when performing an operation are Physical; a) work postures, b) excessive weight / force, c) physical load, among others. And in a matter of Psychosocial Dimensions appear: a) Demands, b) control, c) communication, etc. However, Lean management and VSM analysis focus on waste to identify workflow issues and develop an improved workflow. The Lean mentality and waste analysis teach workers to perform their operations efficiently through lean training. On the other hand Winkel, Doubts, Harlin, Jarebrant, & Hanse, (2013) mention that ErgoVSM facilitates the development of an action plan that can result in greater organizational sustainability compared to traditional VSM. Jarebrant, Winkel, Hanse, Mathiassen, & Öjmertz, (2017) add that ErgoVSM is based on the VSM contributing to the identification and evaluation of the risks that can occur when introducing actions for greater efficiency.

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